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3D Structure of Flinders Ranges from Local Earthquake Tomography

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The Flinders Ranges, situated in the Adelaide Fold Belt, South Australia, lie within a region of relatively high active intra-plate deformation that manifests as a distinct concentration in seismic activity and topographic relief. Unlike most other stable continents, maximum horizontal compressive stress trajectories in the Australian crust do not align with absolute Australian Plate velocity, and have a particularly complicated configuration in the Flinders Ranges area. Although near surface structure has been exhaustively studied via geological mapping, geochemical analysis and potential field data, there is a consistent lack of deep seismic profiling or high resolution 3-D tomographic imaging that could impose important constraints on the broad scale geology of the crust. In this study, local earthquake tomography is carried out in the Flinders Ranges in order to simultaneously improve hypocenter locations, 3-D variations in velocity structure and Moho geometry, with the goal of improving our understanding of crustal structure, rheology, and the mechanism responsible for the localized deformation. The data used for this purpose are traveltimes from approximately 500 local earthquakes, most of which are located above 25 km depth and were recorded by a temporary network of 47 broadband seismometers. In addition to P and S waveforms, the dataset includes Pg, PmP, Pn, Sg, SmS and Sn traveltimes that have been inverted for Moho structure. The solution model has been obtained via an iterative non-linear method that uses a grid-based eikonal solver, known as the Fast Marching Method (FMM), for the forward step of traveltime prediction and the subspace method for velocity structure recovery. The source relocation is performed using a grid-search approach, which finds the minimum misfit in the FMM traveltime grid of an objective function that is based on the difference between observed and predicted traveltimes. One of the main features of the resultant three-dimensional model is a zone of elevated wavespeed that dominates the north-western part of the Flinders Ranges beneath the Neoproterozoic to Cambrian sedimentary package, which contrasts with significantly lower speed to the east. We have attributed these areas to the Gaweler Craton and the Curnamona Province respectively. Another key feature of the solution model is that the boundary between these two main anomalies corresponds to an active seismic zone situated in proximity to a number of major crustal penetrating faults.